GRADUATE ATTRIBUTES

1. **(KB) A knowledge base**: Demonstrated competence in university level language, literature and arts knowledge appropriate to the program.

2. **(PA) Problem analysis**: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex problems in order to reach substantiated conclusions

3. **(Inv.) Investigation**: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data and synthesis of information in order to reach valid conclusions. .

4. **(Team) Individual and teamwork**: An ability to work effectively as a member and leader in teams, preferably in a multi–disciplinary setting.

5. **(Comm.) Communication skills**: An ability to communicate complex concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

6. **(Prof.) Professionalism**: An understanding of the roles and responsibilities in society, especially the primary role of protection of the public and the public interest.

7. **(Impacts) Impact of literature on society and the environment**: An ability to analyze social and environmental aspects. Such ability includes an understanding of the interactions with the social, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

8. **(Ethics) Ethics and equity**: An ability to apply professional ethics, accountability, and equity.

9. **(LL) Life–long learning**: An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The Programme Educational Objectives of the **M.Sc. in Microbiology** Programme at Sourashtra College, Madurai are given below and are numbered from PEO1 to PEO5.

PEO 1	To provide in-depth knowledge about core areas of biosciences such as biotechnology, biochemistry and microbiology.
PEO 2	To make students competent in the field of biosciences and allied areas by providing them hands on experience in basic tools and techniques
PEO 3	To instill the ability for research and entrepreneurship in the students along with strong ethics and communication skills.
PEO 4	To inculcate, facilitate, motivate and promote knowledge technical skills in core areas of biological sciences including advanced tools and techniques like genomics, proteomics and transcriptomics to young aspirants and to equip and motivate the students to pursue higher education and research in reputed institutes at national and international level in the field Science
PEO 5	To develop trained human resource in the field of advanced translational research and to develop graduates with a strong professional ethics and moral duties that will positively affect their profession, community, society and Nation at large.

POSTGRADUATE (PG) PROGRAMME OUTCOMES (POs)

Postgraduate (M.A.,**M.Sc.,**M.Com.,M.Com(CA).,M.B.A.,M.C.A.,etc.,) is a 2 – year degree Programme with 4 semesters consisting the following Programme Outcomes (POs) under various criteria including critical thinking, problem solving, effective communication, societal/ citizenship/ ethical credibility, sustainable growth and employable abilities.

PO 1	**Critical Thinking**: Intellectual exploration of knowledge towards actions in clear and rational manner by understanding the logical connections between ideas and decisions.
PO 2	**Problem Solving**: Understanding the task/ problem followed by planning and narrow execution strategy that effectively provides the solution.
PO 3	**Effective Communication**: Knowledge dissemination by oral and verbal mechanisms to the various components of our society.
PO 4	**Societal/ Citizenship/ Ethical Credibility**: Realization of various value systems/ moral dimensions and demonstrate the empathetic social concern as well as equity in all the decisions, executions and actions.
PO 5	**Environmental Concern and Sustainable Growth**: Understanding the emerging environmental challenges and provide the possible contribution in sustainable development that integrates environment, economy and employment.
PO 6	**Skill Development and Employable Abilities**: Adequate training in relevant skill sector and creating employable abilities among the post graduates.

PROGRAMME SPECIFIC OUTCOMES(PSOs)

M.SC. MICROBIOLOGY PROGRAMME

PSO 1	**Placement** Prepare the students in varied disciplines like agriculture, industry - medical, pharma, dairy, hotel, food and food processing, immunological, cosmetics, vermitechnology and water treatment for effective and respectful placement.
PSO 2	**Entrepreneurship** To create effective entrepreneur by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.
PSO 3	**Research and Development** Design and implement HR systems that comply with good laboratory, practices, following ethical values, leading the organization towards growth and development.
PSO 4	**Contribution to Society** To contribute to the development of society and produce microbiological products, by collaborating with stake holders, related to the betterment of environment and mankind at the national and global level.

DISTRIBUTION OF CREDITS (PG PROGRAMME)

PART	SEMESTER	COURSES	NUMBER OF COURSES	HOURS	CREDITS	TOTAL CREDITS
I	I-II	CORE	8	5-6	4-5	32
I	III-IV	CORE	8	5-6	4-5	40
II	I-II	ELECTIVE	2	5-6	4-5	8
II	IV	ELECTIVE	1	5-6	4-5	5
III	III	NON MAJOR ELECTIVE (NME)	1	6	5	5
TOTAL CREDITS						90

Extra credits may be earned through SWAYAM Courses/other online courses

M.SC. MICROBIOLOGY – II YEAR
COURSE STRUCTURE – III SEMESTER

S. No.	Course Code	Course Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC31	**Core – 7:** Immunology and Microbial Genetics	6	3	25	75	100	5
2.	23PMBC32	**Core – 8:** Molecular Biology and Recombinant DNA Technology	6	3	25	75	100	5
3.	23PMBCP3	**Core – 9:** Practical – III – Immunology, Microbial Genetics and Molecular Biology	6	3	40	60	100	4
4.	**Elective–5: ***		5	3	25	75	100	3
	23PMBE31	Soil Microbiology and Microbial Ecology						
	23PMBE32	Microbial Toxicology						
	23PMBE33	Water Conservation and Water Treatment						
5	23PMBE34	**Elective – 6:** Fermentation Technology and Pharmaceutical Microbiology	5	3	25	75	100	3
6.	23PMBS31	**Skill Enhancement Course-2:** Organic Farming and Biofertiliser Technology	2	3	25	75	100	2
7.	23PMBP31	**Extension Activity:** Internship/Industrial Activity	-	-	-	-	100	2
		TOTAL	**30**					**24**

***One elective course to be chosen from THREE courses**

COURSE STRUCTURE – IV SEMESTER

S. No.	Course Code	Course Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC41	**Core – 10:** Food and Environmental Microbiology	6	3	25	75	100	5
2.	23PMBC42	**Core – 11:** Research Methodology and Biostatistics.	6	3	25	75	100	5
3.	23PMBCP4	**Core – 12:** Practical – IV – Applied Microbiology	6	3	40	60	100	4
4.		**Elective – 7:***	5	3	25	75	100	3
	23PMBE41	Bioenergy						
	23PMBE42	Marine Microbiology						
	23PMBE43	Life Science for Competitive Examinations						
5.	23PMBS41	**Skill Enhancement Course-3:** Microbial Quality Control and Testing	2	3	25	75	100	2
6.	23PMBCV1	**Core – 13:** Project with Viva Voce	5	4	40	60	100	5
		TOTAL	**30**					**24**

***One elective course to be chosen from THREE courses**

COURSE STRUCTURE – III SEMESTER

S. No.	Course Code	Course Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC31	**Core – 7:** Immunology and Microbial Genetics	6	3	25	75	100	5
2.	23PMBC32	**Core – 8:** Molecular Biology and Recombinant DNA Technology	6	3	25	75	100	5
3.	23PMBCP3	**Core – 9:** Practical – III – Immunology, Microbial Genetics and Molecular Biology	6	3	40	60	100	4
4.	**Elective–5: ***		5	3	25	75	100	3
	23PMBE31	Soil Microbiology and Microbial Ecology						
	23PMBE32	Microbial Toxicology						
	23PMBE33	Water Conservation and Water Treatment						
5	23PMBE34	**Elective – 6:** Fermentation Technology and Pharmaceutical Microbiology	5	3	25	75	100	3
6.	23PMBS31	**Skill Enhancement Course-2:** Organic Farming and Biofertiliser Technology	2	3	25	75	100	2
7.	23PMBP31	**Extension Activity:** Internship/Industrial Activity	-	-	-	-	100	2
		TOTAL	**30**					**24**

***One elective course to be chosen from THREE courses**

CA – Class Assessment (Internal)

SE – Summative Examination

T – Theory

P – Practical

Passed in the BoS Meeting held on 09/03/2024 **Signature of the Chairman**

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC31	IMMUNOLOGY, IMMUNOTECHNOLOGY AND MICROBIAL GENETICS	CORE - 7	6	-	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability		Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course has been designed to familiarize the students with cellular, molecular, and biochemical aspects of the development of the immune system and the immune response.

COURSE OBJECTIVES:

- Discuss immunity, organs and cells involved in immunity. Compare the types of antigens and their properties.
- Describe immunoglobulin and its types. Categorize MHC and understand its significance.
- Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development.
- Acquire knowledge the structure DNA in prokaryotes and eukaryotes
- Explain out gene transfer studies in microbes.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity.	Upto K6
CO 2	justify the significance of MHC molecules in immune response and antibody production.	Upto K6
CO 3	design antibodies and evaluate immunological assays in patient samples.	Upto K6
CO 4	analyze genomic DNA of prokaryotes and eukaryotes.	Upto K6
CO 5	summarize gene transfer mechanisms for experimental study.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

IMMUNOTECHNOLOGY AND MICROBIAL GENETICS

UNIT- I:

Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin, development, differentiation, lymphocyte subpopulation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing. Antigen processing and presentation to T- lymphocytes.

UNIT- II:

Immunoglobulin. Theories of antibody production. Class switching and generation of antibody diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation. Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.

UNIT- III:

Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens. Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immuno electrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labeled Assay- Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry. Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.

UNIT- IV:

Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome.

UNIT – V:

Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of *E. coli*, Bacteriophage and Yeast. Importance of transposable elements in horizontal transfer of genes and evolution.

TEXT BOOKS:

1. Coico R., Sunshine G. and Benjamini E. (2003). ***Immunology*** – A Short Course. (5th Edition). Wiley-Blackwell, New York.
2. Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). ***Immunology***, (7th Edition). W. H. Freeman and Company, New York.
3. Abbas A. K., Lichtman A. H. and Pillai S. (2021). ***Cellular and Molecular Immunology***. (10th Edition). Elsevier.
4. Malacinski G.M. (2008). ***Freifelder's Essentials of Molecular Biology***. (4th Edition). Narosa Publishing House, New Delhi.
5. Gardner E. J. Simmons M. J. and Snusted D.P. (2006). ***Principles of Genetics***. (8th Edition). Wiley India Pvt. Ltd.

REFERENCE BOOKS:

1. Travers J. (1997). ***Immunobiology*** - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York.
2. Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). ***Roitt's Essential Immunology***. (11th Edition). Wiley-Blackwell.
3. Hay F. C. and Westwood O. M. R. (2002). ***Practical Immunology*** (4th Edition). Wiley-Blackwell.
4. Glick B. R. and Patten C.L. (2018). ***Molecular Biotechnology*** – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
5. Russell P.J. (2010). Genetics - ***A Molecular Approach***. (3rd Edition). Pearson New International Edition.

DIGITAL TOOLS:

1. https://www.ncbi.nlm.nih.gov/books/NBK279395/
2. https://med.stanford.edu/immunol/phd-program/ebook.html
3. https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4. [PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in
5. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2
CO2	2	3	1	3
CO3	3	3	2	1
CO4	2	1	3	2
CO5	1	3	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC32	MOLECULAR BIOLOGY AND RECOMBINANT DNA TECHNOLOGY	CORE – 8	6	-	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course is designed to provide knowledge on Biological processes which are controlled by different types of phenomena such as cell signaling, replication, transcription, protein expression and cell development.

COURSE OBJECTIVES:

- Provide knowledge on the structure, replication and repair mechanisms of DNA. Illustrate the structure, functions and significance of RNA.
- Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations.
- Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants.
- Impart knowledge on variousmolecular techniques and their importance in biotechnology.
- Explain the applications of genetic engineering in various fields.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	analyze, demonstrate and appreciate DNA replication and protein synthesis.	Upto K6
CO 2	investigate the types of mutation and its impact on microbes. Illustrate various strategies on gene cloning.	Upto K6
CO 3	analyze, modify and characterize DNA modifying enzymes.	Upto K6
CO 4	illustratively assess the molecular techniques for DNA and protein analysis.	Upto K6
CO 5	adopt the applications of Genetic Engineering in the field of agriculture and medicine towards scientific research.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MOLECULAR BIOLOGY AND RECOMBINANT DNA TECHNOLOGY

UNIT – I:

DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Prokaryotic and eukaryotic transcription. Structure and processing of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications.

UNIT- II:

Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion. Silent, conditional and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photo reactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test).

UNIT- III:

Tools and methods in gene cloning. Restriction endonucleases – nomenclature,classification and characteristics -DNA methylases, DNA polymerases, Ligases. Adapters, linkers and homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants. Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors and pGEM3Z) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign genes in bacteria, animal, plant, algae and fungi – merits and demerits.

UNIT- IV:

Genomic DNA and cDNA library - Construction and Screening. Substrative hybridization for tissue specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger's method and automated sequencing methods. Pyrosequencing – DNA chips and micro array. Protein engineering and techniques Site directed mutagenesis – methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. protein folding, protein sequencing, protein crystallization. Applications of protein engineering.

UNIT- V:

Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - transgenic animals, Recombinant Cytokines and their use in the treatment of animal infections. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy - Germ line and Somatic Cell Therapy - Ex-vivo Gene Therapy. In-vivo Gene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants.

TEXT BOOKS:

1. Malacinski G.M. (2008). Freifelder's ***Essentials of Molecular Biology***. (4th Edition).Narosa Publishing House, New Delhi.
2. Snusted D.P. and Simmons M. J. (2019). ***Principles of Genetics***. (7th Edition). JohnWiley and Soms, Inc.
3. Dale J. W., Schantz M.V. and Plant N. (2012). From ***Gene to Genomes*** – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4. Primrose S.B. and Twyman R. M. (2006). ***Principles of Gene Manipulation and Genomics***. (7th Edition). Blackwell Publishing.
5. Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). ***Microbial Genetics***. (2nd Edition). Narosa Publishing House Pvt. Ltd.

REFERENCE BOOKS:

1. Brown T. A. (2016). ***Gene Cloning and DNA Analysis***- An Introduction. (7th Edition).John Wiley and Sons, Ltd.
2. Glick B. R. and Patten C.L. (2018). ***Molecular Biotechnology – Principles and Applications of Recombinant DNA***. (5th Edition). ASM Press.
3. Russell P.J. (2010). Genetics - ***A Molecular Approach***. (3rd Edition). Pearson New International Edition.
4. Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). ***Molecular Genetics of Bacteria***. (4th Edition). ASM Press Washington-D.C. ASM Press.
5. Dale J. W., Schantz M.V. and Plant N. (2012). From ***Gene to Genomes – Concepts and Applications of DNA Technology.*** (3rd Edition). John Wiley and Sons Ltd.

DIGITAL TOOLS:

1. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/
2. https://geneticeducation.co.in/what-is-transcriptomics3.
3. https://www.molbiotools.com/usefullinks.html
4. https://geneticeducation.co.in/what-is-transcriptomics
5. https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	1
CO2	3	1	2	2
CO3	2	3	1	3
CO4	1	2	3	3
CO5	3	3	3	2

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBCP3	PRACTICAL – III - IMMUNOLOGY, MICROBIAL GENETICS AND MOLECULAR BIOLOGY	CORE – 9 PRACTICAL	-	6	4

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	40	60	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

This course is intended to apply the knowledge to understand the microbial physiology, regulation of biochemical pathway and possible modifications for improved control over microorganisms for microbial product synthesis.

COURSE OBJECTIVES:

- Provide adequate skills to perform blood grouping and serological reactions.
- Provide fundamental skills in preparation, separation and purification of immunoglobulin.
- Illustrate the significance of artificial transformation and mutations.
- Familiarize with routine molecular biological techniques.
- Discuss blotting techniques and PCR.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	perform and evaluate immunological reactions to aid Diagnosis.	Upto K6
CO 2	assess the level of lymphocytes in a blood sample and Purify immunoglobulin employing appropriate techniques.	Upto K6
CO 3	perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis	Upto K6
CO 4	utilize various molecular techniques for gene manipulation and detection of mutants.	Upto K6
CO 5	undertake novel research with techniques like PCR and blotting analysis.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

PRACTICAL III - IMMUNOLOGY, MICROBIAL GENETICS AND MOLECULAR BIOLOGY

UNIT- I:

Hematological reactions - Blood Grouping – forward and reverse, Rh Typing Identification of various immune cells by morphology–Leishman staining, Giemsa staining. Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP. Detection of HBs Ag by ELISA. Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID) Immuno-electrophoresis and staining of precipitin lines- Rocket immune electrophoresis and counter current immuno electrophoresis.

UNIT- II:

Preparation of lymphocytes from peripheral blood by density gradient centrifugation. Purification of immunoglobulin– Ammonium Sulphate recipitation. Separation of IgG by chromatography using DEAE cellulose or Sephadex.

UNIT- III:

Artificial Transformation Detection of Antibiotic resistant mutants Identification of mutants by replica plating method.

UNIT- IV:

Isolation of genomic DNA from E. coli and analysis by agarose gel electrophoresis Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) Plasmid DNA isolation from E.coli.

UNIT- V:

Amplification of DNA by PCR Western blotting – Demonstration Southern blotting – Demonstration

TEXT BOOKS:

1. Roitt R.I.M (2001). ***Essential Immunology***.10th Edn. Blackwell Scientific Publishers.
2. Glick B. R. and Patten C. L. (2018). ***Molecular Biotechnology*** – Principles and Applications of Recombinant DNA (5th Edition). ASM Press.
3. Gunasekaran P. (2007). ***Laboratory Manual in Microbiology***. New Age International.
4. James G Cappucino and Natalie Sherman. (2016). ***Microbiology*** – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
5. Russell P. J. (2019). ***Genetics*** – A Molecular Approach (3rd Edition). Pearson Education, Inc.

REFERENCE BOOKS:

1. Stites D.P., Abba I.Terr, Parslow T.G.(1997). ***Medical Immunology***. 9thedn, Prentice-Hall Inc.
2. Tizard, R.I. (2000) ***Immunology***- An Introduction. 4thedn. Saunders College Publishing, Philadelphia.
3. Dale J. W., Schantz M. V. and Plant N. (2012). From ***Gene to Genomes*** – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4. Sambrook J. and Russell D.W. (2001). ***Molecular Cloning: A Laboratory Manual***. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.
5. Brown T.A. (2016). ***Gene Cloning and DNA Analysis***. (7th Edition). John Wiley and Jones, Ltd.

DIGITAL TOOLS:

1. https://www.molbiotools.com/usefullinks.html
2. https://geneticgenie.org
3. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
4. https://vlab.amrita.edu/index.php?sub=3&brch=272
5. https://nptel.ac.in/courses/102105087

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	3
CO2	3	3	2	1
CO3	1	3	3	3
CO4	2	1	3	3
CO5	3	2	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

SOURASHTRA COLLEGE, MADURAI– 625004

(An Autonomous Institution Re-accredited with 'B+' grade by NAAC)

M.Sc. MICROBIOLOGY – SYLLABUS

(Under CBCS based on OBE)(with effect from 2023 – 2024)

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE31	SOIL MICROBIOLOGY AND MICROBIAL ECOLOGY	ELECTIVE 5 – I	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability		Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course is designed to gain a basic understanding of the current methodologies used for surveying soil microbial diversity and the environmental factors influencing microbial distribution and abundance.

COURSE OBJECTIVES:

- Explain the role of microorganisms in soil fertility.
- Discuss the harmful effects of microorganisms in soil.
- Create awareness about microbial interactions.
- Provide in depth knowledge about microbial communities and ecosystem.
- Develop knowledge about quantitative ecology.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation.	Upto K6
CO 2	apply the knowledge on plant pathology in agriculture.	Upto K6
CO 3	utilize the knowledge of microbial interactions in various fields.	Upto K6
CO 4	predict community ecosystem and their dynamics.	Upto K6
CO 5	apply quantitative microbial ecology for the benefit of mankind.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

SOIL MICROBIOLOGY AND MICROBIAL ECOLOGY

UNIT- I:

Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic matter in soil. Biological nitrogen fixation- Chemistry and Genetics of BNF.

UNIT- II:

Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis related (PR) proteins, Plantibodies, Phenolics, and Phytoalexins.

UNIT- III:

Interactions among microbial populations- Single microbial populations, positive and negative interactions. Interaction between diverse microbial populations. Population within biofilms. Interaction between microbes and plants – Rhizosphere and mycorhizae. Interactions with animals – contribution of microbes in animal nutrition and diseases.

UNIT- IV:

Microbial Communities and Ecosystems – Development of microbial community. Microbial community and dynamics and nature. Succession within biofilm communities.

UNIT- V:

Quantitative Microbial Ecology – Sample collection, detection of microbial populations, determination of microbial numbers, detecting non culturable bacteria and determination of microbial biomass.

TEXT BOOKS:

1. Subba Rao. N. S. (2017). ***Soil Microbiology***. (5th Edition). MedTech Publishers.
2. Rangaswami. G. and Mahadevan. A. (2006***). Diseases of Crop Plants in India***. (4th Edition). Prentice–Hall of India Pvt. Ltd
3. Larry.L. Barton and Diana .E. Northup. (2011). ***Microbial Ecology***. Wiley Publishers.
4. McArthur. (2006). ***Microbial Ecology*** – An Evolutionary Approach AP Publishers.
5. Subba Rao. N.S. (2005). ***Soil microorganisms and Plant Growth***. (4th Edition). Oxford and IBH Publishing Pvt. Ltd.

REFERENCE BOOKS:

1. Bartha .A (2009). Microbial Ecology- ***Fundamentals and applications***. 4th Edn. Pearson Education.
2. Robert. LTate. (2003).Soil Science – ***An inter-disciplinary approach to soil research***. Lipincott Williams and Wilkins.
3. Terry J. Gentry and Jeffry. J. Fuhrmann, David A Zuberer. (2021). ***Principle and application of soil Microbiology***. 3rd Edn. Elsevier publications.
4. Shrivastava A.K. (2003). ***Environment Auditing***. A. P. H. Publishing Corporation.
5. Tinsley, S. and Pillai, I. (2012). ***Environmental Management Systems*** – Understanding Organizational Drivers and Barriers. Earth scan.

DIGITAL TOOLS:

1. https://staff.oouagoiwoye.edu.ng
2. http://www.scribd.com
3. www.environmentshumail.blogspot.in/ 101
4. https://www.soinc.org
5. https://www.onlinebiologynotes.com

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	1
CO2	2	3	1	3
CO3	3	1	2	3
CO4	1	2	3	3
CO5	3	3	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

SOURASHTRA COLLEGE, MADURAI– 625004

(An Autonomous Institution Re-accredited with 'B+' grade by NAAC)

M.Sc. MICROBIOLOGY – SYLLABUS

(Under CBCS based on OBE)(with effect from 2023 – 2024)

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE32	MICROBIAL TOXICOLOGY	ELECTIVE 5 – II	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability		Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course covers the basic aspects of microbial toxicology which includes the structure and properties of microbial toxins and methods of identification of microbial toxins at cellular level.

COURSE OBJECTIVES:

- Recognize the various categories of environmental toxins and their hazardous consequence
- Enhance the knowledge of underlying etiology of bacterial diseases.
- Promote technical skills for identification of fungal toxins.
- Gain Knowledge about algal toxins and their effects.
- Illustrate various techniques to isolate and characterize the toxin. Examine, interpret and discuss the certainty of toxic substances.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	perceive the adverse effects of toxin and its potential	Upto K6
CO 2	assess the toxicity, properties and mode of actions of bacterial toxins.	Upto K6
CO 3	explicate the mode of actions and their biological significance of fungal toxins.	Upto K6
CO 4	evaluate the mode of action and consequences of algal toxins.	Upto K6
CO 5	evaluate the toxicity level with the help of advanced techniques.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MICROBIAL TOXICOLOGY

UNIT- I:

General Introduction - Definition of toxins, different categories of toxins.

UNIT- II:

Bacterial toxins - Bacterial toxins Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria and tetanus toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins, neurotoxins and mycotoxins.

UNIT- III:

Fungal Toxins – Structure, Properties of Aflatoxin, Ochratoxin Patulin, Leukosytrine, Trichothecenes, Fumonisins and Ergot alkaloids.

UNIT- IV:

Algal Toxins- Structure, Properties of Cyanotoxins Microcystins, Nodularins, Anatoxin- A, Saxitoxin Aetokthonotoxin. Others- Hepatotoxin, Neu.

UNIT- V:

Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2- dimensional gel electrophoresis).

TEXT BOOKS:

1. Holst O. (2008). ***Bacterial Toxin –Methods & Protocols***. Humana Press.ISBN 9781592590520
2. Shier W. T. (1990). ***Handbook of Toxinology***. CRC Press. ISBN 9780824783747
3. Wilson K. and Walker J. (2010). ***Principles and Techniques of Biochemistry and Molecular Biology.*** (7thEdition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1
4. Pholtan Rajeev S.R. (2021). ***Pictorial handbook for toxinology.*** Rudra Publications
5. Cora Lancester. (2015). ***Molecular Toxinology Handbook***. Callisto Reference

REFERENCE BOOKS:

1. Reilly M. J. (2018). ***Bioinstrumentation.*** CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395.
2. Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, ***Industrial and Environmental Toxicology***. St Louis: C.V. Mosby.
3. Wiley-Vch. (2005). Ullmann's ***Industrial Toxicology***. New York: John Wiley & Sons.
4. Winder C. and Stacey N.H. and Boca Raton F. L. (2004). ***Occupational Toxicology***. (2nd Edition). CRC Press
5. Gopalakrishnakone(2015). ***Biological Toxins and Bioterrorism***. Springer

DIGITAL TOOLS:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/
2. https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE
3. https://www.toxinology.org/
4. https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology
5. https://pubmed.ncbi.nlm.nih.gov/12807310

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	1
CO2	3	1	2	3
CO3	1	3	3	2
CO4	3	2	1	3
CO5	2	3	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE33	WATER CONSERVATION AND WATER TREATMENT TECHNOLOGIES	ELECTIVE 5 – III	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course is intended to provide knowledge on the technologies that optimize water system efficiency and promote sustainability resulting in a high-performance water conservation and also to gain familiarity on Water Quality &Pollution and Water Treatment Technologies.

COURSE OBJECTIVES:

- Explain how societal and climatic changes will distress water supply and water demand in future
- Ascertain promising elucidations to the global water crisis and assess the pros and cons
- Provide knowledge to identify the quality of water by standard method
- Illustrate the methods of water treatment technologies and assessing the impact of HWTS
- Describe the application and uses of various emerging water treatment technologies

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	appraise issues of water scarcity, stress, and conflict on global population.	Upto K6
CO 2	apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation.	Upto K6
CO 3	relate the connection between water quality and public health.	Upto K6
CO 4	design and execute standard strategy for successful HWTS implementation.	Upto K6
CO 5	cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

WATER CONSERVATION AND WATER TREATMENT TECHNOLOGIES

UNIT- I:

Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint- Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India - Social and Political Effects and Economic Risks of Water Scarcity in India

UNIT- II:

Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir, Desalination Plants Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.

UNIT- III:

Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.

UNIT- IV:

Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration, Water disinfection, Activated carbon filtration, Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree, Assessing the impact of HWTS, Government policies for HWTS.

UNIT- V:

New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Aquaporin Inside™ technology, Automatic Variable Filtration (AVF) technology, Sun Spring System, Desalination.

TEXT BOOKS:

1. Vasileios A., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). ***Water Supply and Water Scarcity***. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3- 03943-3070.
2. Pannirselvam M., Shu Li.,Griffin G., Philip L., Natarajan A. and Hussain S. 2019. ***Water Scarcity and Ways to Reduce the Impact***.ISBN:978-3-319-75199-3.
3. Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). ***Water Scarcity, Contamination and Management***. Elsevier. ISBN: 9780323853781.

4. Daniel, C.J. (1996). ***Environmental Aspects of Microbiology***, 1st edn. Bright Sun Publications. 3.
5. Maier RM, Pepper IL, Gerba CP (2008). ***Environmental Microbiology***, 2nd edn. Academic Press 4.

REFERENCE BOOKS:

1. Fujita K. and Mizushima T. (2021). ***Sustainable Development in India*** - Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976.
2. Gupta R. (2008). ***Water Crisis in India. Atlantic Publishers***. ISBN: 9788126909582, 9788126909582. 107
3. Ahuja S. (2013). ***Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation.*** Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955.
4. Saeid Eslamian., Faezeh Eslamian , (2021) ***Water harvesting and conservation – Basic Concepts and fundamentals***, Wiley Publications.
5. Buckley RG. (2016) ***Environmental Microbiology*** 1st edn. CBS Publishing.

DIGITAL TOOLS:

1. https://link.springer.com/book/10.1007/978-1-59745-278-6
2. https://apps.who.int/iris/handle/10665/206916?show=full
3. https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html
4. https://www.toftigers.org/best-practice/water-conservation-and-treatment/
5. https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	3
CO2	3	3	2	1
CO3	2	2	3	3
CO4	3	3	1	3
CO5	2	1	3	2

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE34	FERMENTATION TECHNOLOGY AND PHARMACEUTICAL MICROBIOLOGY	ELECTIVE – 6	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

This course covers the basic principles of fermentation and technologies of upstream and Downstream Processing. The students will learn overview of pharmaceutical microbiology and Production of pharmaceutical products

COURSE OBJECTIVES:

- Discuss fermentation and its types, sensitize on methods of strain development for improved yield.
- Impart knowledge on the fermenter design and types.
- Provide knowledge on the effective recovery and purification of the products.
- Explain the importance of pharmaceutical microbiology.
- Illustrate methods for production products using microorganisms and their quality control.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	develop microbial strains, carry out fermentation and recover the products of the process.	Upto K6
CO 2	design fermenters according to needs for various products.	Upto K6
CO 3	recover the end products of the fermentation process economically.	Upto K6
CO 4	utilize the knowledge on pharmaceutical microbiology for industrial production of products.	Upto K6
CO 5	produce therapeutic products from microbes employing technology and analyze the quality the products.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

Passed in the BoS Meeting held on 09/03/2024 **Signature of the Chairman**

FERMENTATION TECHNOLOGY AND PHARMACEUTICAL MICROBIOLOGY

UNIT- I:

Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter preculture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic

UNIT- II:

Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.

UNIT- III:

Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phases, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization

UNIT- IV:

Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and noninjectable, ophthalmologic preparation, implants.

UNIT- V:

Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.

TEXT BOOKS:

1. Patel A. H. (2016). ***Industrial Microbiology.*** (2nd Edition). Laxmi Publications, New Delhi.
2. Casida L. E. J. R. (2019). ***Industrial Microbiology***. New Age International Publishers.
3. Sathyanarayana U. (2005). ***Biotechnology***. (1st Edition). Books and Allied (P) Ltd.
4. Reed G. (2004). ***Prescott and Dunn's Industrial Microbiology***. (4th Edition). CBS Publishers & Distributors.
5. Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). ***Industrial Microbiology: An Introduction.*** Wiley Blackwell Publishers.

REFERENCE BOOKS:

1. Stanbury P. T. and Whitaker. (2016). ***Principles of Fermentation Technology***. (3rd Edition). Pergamon Press. NY
2. Handa S. S. and Kapoor V. K. (2022). ***Pharamcognosy,*** (4th Edition). Vallabh Prakashan Publishers, New Delhi.
3. Kokate C. K., Durohit A. P. and Gokhale S. R. ***Pharmacognosy***. (2002). (12th Edition). Nirali Prakasham Publishers, Pune.
4. Hugo W. B. and Russell A. D. (2004). ***Pharmaceutical Microbiology***. (7th Edition). Blackwell Scientific Publication, Oxford.
5. Wallis, T.E. (2005). ***Text book of Pharmacognosy***. (5th Edition). CBS publishers and distributors, New Delhi.

DIGITAL TOOLS:

1. https://ib.bioninja.com.au/options/untitled/b1-microbiology
2. https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicilli%20n.html
3. https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation
4. https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q0
5. http://www.simbhq.org/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**3**
CO2	**1**	**3**	**3**	**3**
CO3	**3**	**1**	**1**	**2**
CO4	**2**	**3**	**2**	**2**
CO5	**3**	**2**	**3**	**1**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBS31	ORGANIC FARMING AND BIOFERTILIZER TECHNOLOGY	SKILL ENHANCEMENT COURSE – 2	2	-	2

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	III	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

This course is designed to develop critical understanding on various aspects of agronomy, plant nutrition, cropping methods and crop rotation.

COURSE OBJECTIVES:

- Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture.
- Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends.
- Explain the various types of biofertilizer and the scope in its production.
- Discuss biofertilizer production and its field application, promoting economy.
- Develop the skill to analyze the quality of packaging, storage, assess the shelf life and efficacy of biofertilizers

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	produce biofertilizers and distinguish between organic and conventional farming.	Upto K6
CO 2	plan a complete farm business including marketing, operation and financial outline.	Upto K6
CO 3	practise the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility.	Upto K6
CO 4	develop integrated farming for sustainable agriculture	Upto K6
CO 5	promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per bis standards	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

ORGANIC FARMING AND BIOFERTILIZER TECHNOLOGY

UNIT- I:

Organic farming – Definition, relevance. Biological nutrient management - Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison

UNIT- II:

Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system definition, goal, and components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY.

UNIT- III:

Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia*.

UNIT- IV:

Cyanobacterial biofertilizers- Anabaena, Nostoc, Hapalosiphonand fungal biofertilizers- AM mycorrhiza and ectomycorhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization

UNIT- V:

Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.

TEXT BOOKS:

1. Sharma A. K. (2001). ***Hand book of Organic Farming***. Agrobios.
2. Gaur A. C. (2006). ***Hand book of Organic Farming and Biofertilizers***. Ambika Book Agency.
3. Subba Rao N.S. (2017). ***Bio-fertilizers in Agriculture and Forestry***. (4th Edition). Med Tech publisher.
4. Subba Rao N. S. (2002). ***Soil Microbiology. Soil Microorganisms and Plant Growth***. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Sathe T.V (2004). ***Vermiculture and Organic Farming***. Daya Publishers.

REFERENCE BOOKS:

1. Rakshit A. and Singh H. B. (2015). ***ABC of Organic Farming***. (1st Edition). Jain Brothers.
2. Dubey R. C. (2008). ***A Textbook of Biotechnology***. S. Chand & Co., New Delhi.
3. Bansal M. (2019). ***Basics of Organic Farming***. CBS Publisher.
4. Bhoopander G., Ram Prasad., (2019) ***Biofertilizer for sustainable agriculture and Environment,*** Springer
5. Niir Board., (2012) (1st Edition) ***Biofertiliser and organic farming***

DIGITAL TOOLS:

1. https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html
2. https://www.fao.org/organicag/oa-faq/oa-faq6/en/
3. https://www.india.gov.in/topics/agriculture/organic-farming
4. https://agriculture.nagaland.gov.in/bio-fertilizer/
5.https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCowIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**2**	**1**	**3**
CO2	**3**	**3**	**2**	**1**
CO3	**1**	**3**	**3**	**2**
CO4	**2**	**1**	**3**	**3**
CO5	**3**	**2**	**3**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE STRUCTURE – IV SEMESTER

S. No.	Course Code	Course Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC41	**Core – 10:** Food and Environmental Microbiology	6	3	25	75	100	5
2.	23PMBC42	**Core – 11:** Research Methodology and Biostatistics.	6	3	25	75	100	5
3.	23PMBCP4	**Core – 12:** Practical – IV – Applied Microbiology	6	3	40	60	100	4
4.		**Elective – 7:***	5	3	25	75	100	3
	23PMBE41	Bioenergy						
	23PMBE42	Marine Microbiology						
	23PMBE43	Life Science for Competitive Examinations						
5.	23PMBS41	**Skill Enhancement Course-3:** Microbial Quality Control and Testing	2	3	25	75	100	2
6.	23PMBCV1	**Core – 13:** Project with Viva Voce	5	4	40	60	100	5
		TOTAL	**30**					**24**

***One elective course to be chosen from THREE courses**

CA – Class Assessment (Internal)

SE – Summative Examination

T – Theory

P – Practical

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC41	FOOD AND ENVIRONMENTAL MICROBIOLOGY	CORE – 10	6	-	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course is designed to provide basic knowledge on application of microbiology on the area of food production and environment protection and sustainability.

COURSE OBJECTIVES:

- Discuss microorganisms involved in food spoilage.
- Illustrate bacterial and nonbacterial food borne infections important in public health. Familiarize various national and international aspects of food safety and quality assurance.
- Create awareness. about components of environment, environmental pollution, and detection methods.
- Acquire in depth knowledge about solid and liquid waste treatments.
- Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	utilize the knowledge on process of food contamination and spoilage to preserve food.	Upto K6
CO 2	use the knowledge on food borne disease to protect public health.	Upto K6
CO 3	explain the different types of microorganisms in water. identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases.	Upto K6
CO 4	apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup.	Upto K6
CO 5	Plan a clear approach on environmental issues. Control pollution and explain protection laws to public.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

FOOD AND ENVIRONMENTAL MICROBIOLOGY

UNIT- I:

Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat and milk products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.

UNIT- II:

Food microbiology and public health. Food hazards. Food Bacterial infections. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus. Microbiological quality standards for food. Government regulatory practices and policies-FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives.

UNIT-III:

Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology -Microbiological research in space environment.

UNIT- IV:

Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management.

UNIT- V:

Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4- D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotic - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies and Environmental laws in India. Environmental impact assessment, EIA guidelines, US Environment protection Agency norms.

TEXT BOOKS:

1. Adams M. R. and Moss M. O. (1996). ***Food Microbiology***, New Age International (P) Limited Publishers, New Delhi.
2. Frazier W.C., Westhoff. D.C. and Vanitha K.N. (2013). ***Food Microbiology***. (6th Edition). McGraw Hill Education.
3. Jay J. M., Loessner M. J. and Golden D.A. (2006). ***Modern Food Microbiology***. (7th Edition). Springer.
4. Shrivastava A.K. (2003). ***Environment Auditing***. A. P. H. Publishing Corporation.
5. Tinsley, S. and Pillai, I. (2012). ***Environmental Management Systems – Understanding Organizational Drivers and Barriers***. Earthscan.

REFERENCE BOOKS:

1. Robinson R. K. (2000). ***Dairy Microbiology*** 3rdEdn, Elsevier Applied Science, London.
2. Hobbs, B.C. and Roberts, D, (1968), ***Food Poisoning and Food Hygiene*** 7th Edn. Edward Arnold: London.
3. Banwarst. G.J. (2003). ***Basic Food Microbiology*** 2nd Edn, CBS Publishers and distributors.
4. Bitton, G. (2011). ***Wastewater Microbiology***. (4th Edition). Wiley- Blackwell.
5. Bridgewater L. (2012). ***Standard Methods for the Examination of Water and Wastewater***. American Public Health Association.

DIGITAL TOOLS:

1. https://www.fssai.gov.in
2. https://www.who.int/news-room/fact-sheets/detail/food-safety
3. https://egyankosh.ac.in
4. https://journals.sagepub.com/doi/abs/10.1177/0734242x14535653
5. https://www.biologydiscussion.com/microbiology-2/bioremediation/xenobiotic-compounds-meaning-hazards-and-biodegradation/55625

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	3
CO2	2	3	3	1
CO3	2	1	3	3
CO4	1	2	2	3
CO5	3	3	2	2

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC42	RESEARCH METHODOLOGY AND BIOSTATISTICS	CORE – 11	6	-	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
III	IV	25	75	100

NATURE OF COURSE	Employability		Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course is designed to provide an overview of research methodology including basic concepts employed in quantitative and qualitative research methods and statistical approaches used in processing biological information.

COURSE OBJECTIVES:

- Discuss the methods and techniques of data collection.
- Explain sampling methods, write research reports and articles.
- Discuss the basic concepts of Biostatistics.
- Describe statistical software for analysis.
- Explain the tests of significance.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	collect and present data suitable to the research design.	Upto K6
CO 2	write research manuscripts and articles for journals.	Upto K6
CO 3	recommend the utilization of biostatistics tools for analysis of biological data.	Upto K6
CO 4	prove and justify hypothesis for a particular research.	Upto K6
CO 5	apply software tools for interpretation of biological data.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

RESEARCH METHODOLOGY AND BIOSTATISTICS

UNIT- I:

Introduction to Research Methodology - Meaning and importance. Statement,Constraints. Review of literature - Review and synopsis presentation. Types of research, Research tools. Methods and techniques of data collection - types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection..

UNIT- II:

Sampling and sampling distributions. Sampling frame, importance of probability sampling, sampling - simple random, systematic, stratified random and cluster. Variables - nominal, ordinal, discontinuous, continuous, derived. Research process, designs and Report writing - types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

UNIT- III:

Introduction to Biostatistics-Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. Measures of central tendency: Mean, Median, Mode. Measures of variability - Standard deviation, standard error, range, mean deviation and coefficient of variation. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient.

UNIT- IV:

Correlation and regression - Positive, negative, calculation of Karl-Pearsons co-efficient of correlation. Linear regression and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation. Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error.

UNIT- V:

Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. RSM: methods for process optimization set up CCD, Box Behnken, optimal RSM design, regression models FDS curves, surface contours, multi linear constraints and categoric factors to optimal design.

TEXT BOOKS

1. Sharma K. R. (2002) ***Research methodology***. National Publishing House, New Delhi.
2. Daniel W.W. (2005). ***Biostatistics; A foundation for analysis in the health sciences***. (7th Edition). John Wiley & sons Inc, New York.
3. Rao P. S. S. and Richard J. (2006). ***Introduction to Biostatistics & Research methods.*** Prentice-Hall, New Delhi.
4. Veerakumari L. (2015) ***Bioinstrumentation*** 1st edn. MJP Publishers.
5. Ahuja V.K. (2017) ***Laws Relating to Intellectual Property Rights***. Lexis Nexis.

REFERENCE BOOKS:

1. Zar J. H. (2006). ***Biostatistical Analysis***. (4th Edition). Pearson Education Inc. New Jersey.
2. Beins B. C. and McCarthy M.A. (2011). ***Research Methods and Statistics***. Pearson Education Inc. New Jersey.
3. Adams K. A. and Lawrence E. M. K. (2014). ***Research Methods, Statistics, and Applications.*** SAGE Publications, Inc., New Delhi.
4. Anderson J.B. and Poole M. (2011). ***Assignment and Thesis Writing***. 4th edn. Wiley India Private Limited.
5. Kothari C.R. and Garg G (2004) ***Research Methodology: Methods and Techniques.*** 2nd Edition. New Age International Publishers

DIGITAL TOOLS:

1. https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093
2. https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library
3. https://testbook.com/learn/maths-mean-median-mode/
4. https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%20Correlation%20and%20Regression.pdf
5. https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	1
CO2	2	1	2	3
CO3	1	3	3	2
CO4	3	2	1	3
CO5	3	3	3	2

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBCP4	PRACTICAL IV- APPLIED MICROBIOLOGY	CORE – 12	-	6	4

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	40	60	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

The course gives an overview on the utilization and application of microbes in different industries that enrich human lives and environmental sustenance.

COURSE OBJECTIVES:

- Enumerate bacteria in milk for food quality analysis.
- Analyze methods for microbial identification that causes food spoilage.
- Gain knowledge on microbes present in water.
- Identification and characterization of nitrogen fixers.
- Gain knowledge on biofertilizer production and field application.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	check the quality of milk	Upto K6
CO 2	identify bacteria and fungi in spoiled food	Upto K6
CO 3	analyze potability of water	Upto K6
CO 4	check the microbial population in air.	Upto K6
CO 5	prepare, apply and check the efficiency of biofertilizers.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

PRACTICAL IV – APPLIED MICROBIOLOGY

UNIT- I:

Breed count, Direct microscopic count and Standard plate count of Milk, Methylene blue reductase test, Resazurin test and alkaline phosphatase test of milk.

UNIT- II:

Isolation of bacteria, fungi and yeast from spoiled and canned food. Production and detection of aflatoxins from spoiled food.

UNIT- III:.

Microbial Analysis of water – MPN, Membrane filtration. Chemical - BOD.

UNIT- IV:

Enumeration of bacteria and fungi from air – Air sampler Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules of leguminous plants. Isolation and enumeration of phosphate-solubilizing bacteria from soil

UNIT- V:

Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers, R:S ratio of soil microbes Study of phylloplane microflora by leaf impression method Isolation of cellulose degrading bacteria. Isolation of plant pathogen – *Alternaria, Curvularia*, Cultivation of mushroom from solid waste

TEXT BOOKS:

1. Ray B. and Bhunia A. (2013). ***Fundamentals of Food Microbiology***. (5th Edition). CRC Press.
2. Garg N., Garg K. and Mukerji K. G. (2013). I K. ***Microbiology*** International Pvt. Ltd.
3. Pepper I., Gerba C. and Brendecke J. (2004). ***Environmental Microbiology*** - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier.
4. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). ***Manual of Environmental Microbiology***. (4th Edition). Wiley.
5. Adams M.R, and Moss M.D, (2005). ***Food Microbiology*** 4th Edition, New Age International Pvt. Ltd., Publishers. First edition.

REFERENCE BOOKS:

1. Hobbs, B.C. and Roberts, D, (1968), ***Food Poisoning and Food Hygiene*** 7th Edition Edward Arnold: London.
2. Vijaya R K, (2004). ***Food Microbiology*** 1st Edition. MJP Publishers, Chennai.
3. Banwarst. G.J. (2003). ***Basic Food Microbiology*** 2nd Edition, CBS Publishers and distributors.
4. James G Cappucino and Natalie Sherman. (2016). ***Microbiology*** – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
5. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). ***Manual of Environmental Microbiology***. (3rd Edition). American Society for Microbiology.

DIGITAL TOOLS:

1. https://www.fssai.gov.in
2. https://www.who.int/news-room/fact-sheets/detail/food-safety
3. https://academic.oup.com/bioscience/article/65/8/758/240222
4. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
5. https://vlab.amrita.edu/index.php?sub=3&brch=272

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	3
CO2	2	3	3	1
CO3	3	1	3	3
CO4	2	3	2	2
CO5	1	2	3	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE41	BIOENERGY	ELECTIVE 7 – I	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

This course provides an understanding on the sustainable utilization of biomass fuels and in-depth knowledge of fuel characterization, treatment and conversion technologies using environmental microorganisms related to bioenergy.

COURSE OBJECTIVES:

- Acquire knowledge on bioenergy utilizing organic wastes for energy recovery.
- Discuss methods and strategies of exploiting microbes for the production technology of biodiesel.
- Describe resources and techniques for the production and estimation of eco-friendly biofuels and the extent of their use potentially.
- Gain knowledge for executing biogas plant in communities.
- Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	evaluate the various aspects of biomass production and their implementation.	Upto K6
CO 2	design and construct a biodiesel plant.	Upto K6
CO 3	carry out the process of fermentation for bio – alcohol fuels.	Upto K6
CO 4	identify the nature of biogas as a biofuel and their technologies and applications.	Upto K6
CO 5	design, execute and extract biohydrogen from algae.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

BIOENERGY

UNIT- I:

Bioenergy – Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) - Bioprospecting of microbial strains for biofuel production.

UNIT- II:

Biodiesel − Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms (*Cryptococcus, Cunninghamella, Mortierella*).

UNIT- III:

Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.

UNIT- IV:

Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture**.**

UNIT- V:

Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus* and *Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.

TEXT BOOKS:

1. Dahiya A. (2014). ***Bioenergy***- Biomass to Biofuel. (1st Edition). Academic Press Editor.
2. Brown R. C. (2003). ***Biorenewable Resources***: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing.
3. Jawaid M., Hakeem K. R. and Rashid U. (2014). ***Biomass and Bioenergy***: Processing and Properties. (1st Edition). Springer Cham.
4. Caye M. Drapcho, Tery H. Walke ***Biofuels Engineering Process Technology***. McGraw Hill.
5. Teri. ***Bio energy powering the Future***. Pearson Longman Publications.

REFERENCE BOOKS:

1. Konur O. (2018). ***Bioenergy and Biofuels***. (1st Edition). CRC Press.
2. Lee J. W.(2012). ***Advanced Biofuels and Bioproducts***. (13th Edition), Springer.
3. Khanal S. (2008). ***Anaerobic Biotechnology for Bioenergy Production***: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing.
4. Pradeep Chaturvedi.(1995). ***Bioenergy Resources***. Concept Publishing Company.
5. Lee S. (2018).***Biofuel and Bioenergy***. Taylor and Francis

DIGITAL TOOLS:

1. https://www.elsevier.com Biofuels and Bioenergy
2. https://www.sciencedirect.com › book › bioenergy
3. https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE
4. https://www.energy.gov/eere/bioenergy/bioenergy-basics
5. https://www.iea.org/fuels-and-technologies/bioenergy

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**2**	**1**	**3**
CO2	**2**	**3**	**3**	**2**
CO3	**1**	**3**	**3**	**3**
CO4	**3**	**1**	**2**	**3**
CO5	**3**	**2**	**3**	**1**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE42	MARINE MICROBIOLOGY	ELECTIVE 7 – II	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	25	75	100

NATURE OF COURSE	Employability		Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course is designed to gain knowledge on global warming, dynamics of marine microbes and different environmental factors which affect the marine microorganisms. This course also focuses on the marine microbial diseases, aquaculture and the applications of marine microbial biotechnological products.

COURSE OBJECTIVES:

- Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans.
- Discuss the metabolic diversity of marine microorganisms and their interrelationships.
- Explain the survival of microorganisms in extreme environments.
- Illustrate pathogens and contaminants in sea foods.
- Describe the applications of marine biotechnological products and their future role in a rapidly changing planet.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apply the knowledge on marine microbial communities and their interactions.	Upto K6
CO 2	illustrate the role of marine microorganisms in biogeochemical	Upto K6
CO 3	categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments.	Upto K6
CO 4	identify the diseases affecting marine organisms and its diagnosis.	Upto K6
CO 5	evaluate the marine microorganisms as a resource for novel microbial products.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MARINE MICROBIOLOGY

UNIT- I:

Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.

UNIT- II:

Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials.

UNIT- III:

Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology.

UNIT- IV:

Marine Microbial Diseases: Aqua culture pathogens & Water borne pathogens - *Aeromonas, Vibrio, Salmonella, Pseudomonas, Leptospira, Corynebacteria* and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.

UNIT- V:

Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.

TEXT BOOKS:

1. Munn C. B. (2019). ***Marine Microbiology: Ecology and Applications***. (3rd Edition). CRC Press. ISBN: 9780367183561.
2. Bhakuni, D.S. and Rawat D. S. (2005). ***Bioactive Marine Natural Products***. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5.
3. Brock T. D. (2011). ***Thermophilic Microorganisms and Life at High Temperatures.*** Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860.
4. Nybakken, J.W. (2001). ***Marine Biology.*** (5th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764.
5. Veena. ***Understanding marine biology.*** Discovery Publishing.

REFERENCE BOOKS:

1. Maier R. M., Pepper I. L. and Gerba C. P. (2006). ***Environmental Microbiology***. (2nd Edition). Academic Press. ISBN: 978-0-12-370519-8.
2. Belkin S. and Colwell R. R. (2005). ***Oceans and Health: Pathogens in the Marine Environment***. Springer. ISBN: 978-0-387-23708-4.
3. Scheper T. (2009). ***Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology***. Springer. ISBN: 978-3-540-69356-7. E-ISBN: 978-3-540-69357-4.
4. Gasol J. M. and Kirchman D. L. (Eds.). (2018). ***Microbial Ecology of the Oceans***. (3rd Edition). Wiley-Blackwell. ISBN: 978-1-119-10718-7.
5. Kim S. K. (2019). ***Essentials of Marine Biotechnology***. Springer.

DIGITAL TOOLS:

1. https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1
2. https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products
3. http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf
4. https://link.springer.com/book/10.1007/b102184
5. https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**2**	**1**	**3**
CO2	**2**	**3**	**2**	**1**
CO3	**3**	**1**	**3**	**3**
CO4	**1**	**2**	**3**	**3**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE43	LIFE SCIENCES FOR COMPETITIVE EXAMINATIONS	ELECTIVE 7 – III	5	-	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

This course expands the horizon of a student about the flora and fauna, giving a thorough base over the subject which helps in finding bright future options through clearing competitive examinations.

COURSE OBJECTIVES:

- Impart knowledge on structure, metabolism and function of biomolecules.
- Understand the importance of inheritance biology. .
- Discuss in-depth about the different types of ecosystems and their importance.
- Outline the major drivers in biodiversity and various conservation approaches.
- Introduce basic concepts of evolution and biological clock.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	define, classify and assess the structure, biological functions and interactions of Biomolecules.	Upto K6
CO 2	validate the knowledge of collective and progressive notions of cellular organization.	Upto K6
CO 3	assess and describe the importance of inheritance biology.	Upto K6
CO 4	establish acquaintance and understanding of ecology & biodiversity in a broader sense.	Upto K6
CO 5	understand the processes of evolution, relate with natural selection, adaptation and speciation.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

LIFE SCIENCES FOR COMPETITIVE EXAMINATIONS

UNIT- I:

Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Bioenergetics.

UNIT- II:

Cellular Organization, Cell division and cell cycle, Membrane structure and function, Organization of genes and chromosomes, Structural organization and function of intracellular organelles, DNA replication, repair and recombination, Protein synthesis and processing.

UNIT- III:

Inheritance Biology, Mendelian principles- Dominance, segregation, independent assortment, Linkage and Gene mapping, Karyotyping, Extra chromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

UNIT- IV:

Ecology- Habitat and Niche, biotic and abiotic interactions, Biome- biogeographical zones of India. Ecological Succession, Population Ecology- Characteristics of a population; population growth curves, Environmental pollution-global environmental change, Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).

UNIT- V:

Evolution and Behaviors- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution- Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.

TEXT BOOKS:

1. Nelson D. L. and Cox M. M. (2008). ***Lehningers Principles of Biochemistry***. (5th Edition). W.H. Freeman and Company.
2. Chapman J. L. (1998).***Ecology: Principles and Applications***. (2nd Edition). Cambridge University Press.
3. Krishnamurthy V. K. (2003). ***Textbook of Biodiversity***. Science Publishers.
4. Rogers A. L. (2011). ***Evidence of Evolution. University of Chicago Press***. Chicago.
5. Stites D.P.,Abba I.Terr, Parslow T.G.(1997). ***Medical Immunology***. 9thEdn, Prentice-Hall Inc.

REFERENCE BOOKS:

1. Pontarotti P. (2018). ***Origin and Evolution of biodiversity***. (1st Edition). Springer.
2. Verma P. S. and Agarwal V. K. (2004). ***Cell biology, Genetics, Molecular Biology, Evolution and Ecology.*** (2nd Edition). S Chand publication.
3. Lewin R. and Foley R. (2004). ***Principles of Human Evolution***. (2nd Edition). Black well Publishing Company.
4. Boyer R.F. (2002) ***Modern Experimental Biochemistry 3rd Edition.*** Pearson Education.
5. Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's ***Principles and Techniques of Biochemistry and Molecular Biology*** 8th Edition. Cambridge University Press.

DIGITAL TOOLS:

1. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_
2. https://www.livescience.com/474-controversy-evolution-works.html.
3. https://www.examrace.com/Study-Material/Life-Sciences/
4. https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts
5. https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	3
CO2	2	1	3	3
CO3	1	3	2	3
CO4	3	2	3	1
CO5	2	3	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBS41	MICROBIAL QUALITY CONTROL AND TESTING	SKILL ENHANCEMENT COURSE – 3	2	-	2

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	25	75	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

COURSE DESCRIPTION:

This course is designed to provide knowledge on Microbiological Quality Control (QC) that allows microbiologists to monitor and protect against microbial impurities in bio-manufacturing production systems.

COURSE OBJECTIVES:

- Explain various microbiological quality standards for food, water and air regulatory practices and policies.
- Discuss collection, processing and preservation of water samples from industries in different areas.
- Enumeration and isolation of microorganism from the water samples.
- Enumeration and isolation of microorganism from the air samples.
- Gain knowledge on sterility testing of different components in industries and quality control techniques.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apply knowledge in quality analysis techniques suitable for industries.	Upto K6
CO 2	perform water managements, water harvesting and treat sewage, water pollutions and remedies.	Upto K6
CO 3	detect portability of water and test water quality.	Upto K6
CO 4	impart knowledge on bioaerosols, impact and prevention	Upto K6
CO 5	apply quality control techniques for food and pharma products	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MICROBIAL QUALITY CONTROL AND TESTING

UNIT- I:

Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.

UNIT- II:

Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies.

UNIT- III:

Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Waterborne pathogens, water-borne diseases. Control of waterborne pathogens - Precipitation, chemical disinfection, filtration, high temperature, UV light.

UNIT- IV:

Microflora of air - Bioaerosols, Airborne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation, and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration.

UNIT- V:

Quality control in food - Food X-ray inspection, PPE Equipment, IoT sensors, preventive quality control, and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.

TEXTBOOKS:

1. Aneja R. P., Mathur B.N., Chandan R. C. and Banerjee, A. K. (2002). ***Experiments in Microbiology.***
2. Adams M. R. and Moss M. O. (2006). ***Food Microbiology***. (2nd Edition). Royal Society of Chemistry.
3. Dubey R.C. and Maheshwari D. K. (2010). ***Practical Microbiology***. S. Chand. 137 .
4. Cappuccimo, J. and Sherman, N. (2002). ***Microbiology***: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi.
5. Rosamund M. Baird., Norman A. (2019). ***Handbook of Microbiological quality control in Pharmaceuticals and Medical Devices***. CRC Press.

REFERENCE BOOKS:

1. Cullimore D. R. (2010). ***Practical Atlas for Bacterial Identification***. (2nd Edition). - Taylor &Francis.
2. Sundararaj T. (2003). ***Microbiology Laboratory Manual***. (2 nd Edition). Published by A. Sundararaj
3. Hoges N. A., Denyer S P. and Baird R.M. (2003). ***Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals***, cosmetics & Toiletries. by Sally F. Bloomfield
4. Amitava Mitra. ***Fundamentals of Quality control and Improvement***. (3rd Edition). Wiley Publications
5. David Roesti, Marcel Goverde (2019). ***Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing***. Wiley Publishers.

DIGITAL TOOLS:

1. https://www.researchgate.net › publication › 320730681
2. https://www.fssai.gov.in
3. 3.https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmpetc
4. https://www.who.int/news-room/fact-sheets/detail/food-safety
5. 5.https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccpprinciples-application-guidelines

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CO5	3	3	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBCV1	PROJECT WITH VIVA VOCE	CORE – 13 PROJECT	-	5	4

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
II	IV	40	60	100

NATURE OF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	✓

OBJECTIVES OF THE COURSE:

To impart advanced practical knowledge to conduct a research project. To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes. Present the project in any regional/national conference/seminar during the second year of the course and submit for final semester examinations. The work has to be conducted in department under the guidance of the project supervisor. Interdisciplinary collaborations from external departments / institutions can be organized only for essential areas of the project. Industrial visit has been included along with the project work as a report (minimum of 10 pages) possibly with geo-tagged photographs. The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

Internal (2 out of 3 presentations)	-	25 Marks
Viva	-	15 Marks
Project	-	60 Marks